Ventura County (Calif.). Planning Division.

Seismic safety element : technical appendix.
[1974]

88 01578 10/16/87 3.00
4.83 .18
3.18

SEISMIC SAFETY ELEMENT

TECHNICAL APPENDIX

APPENDIX A-1

GEOLOGY

SOUTHERN VENTURA COUNTY*

A. INTRODUCTION AND SUMMARY

This report is the result of a cooperative agreement study between the California Division of Mines and Geology and the Ventura County Department of Public Works; it was supported in part by a grant from the U. S. Geological Survey which is hereby gratefully acknowledged. The study consisted of compilation of a geologic map at a scale of 1:48,000, a reconnaissance landslide map at the same scale, an inventory of the mineral resources, and a preliminary investigation of late Quaternary sedimentation and seismicity and late Quaternary faulting. The study region encompasses nearly one thousand square miles.

Southern Ventura County is part of the Transverse Range geomorphic province of California. In this province, geologic structures trend mostly east, in contrast to the prevailing northwest trend elsewhere in the state. The geology of the southern Ventura County part of the province is dominated by the Ventura basin, which extends westerly under the present Pacific Ocean. This is an east-trending region that has been down-warped, for the most part, during the last 60 to 75 million years, and in which has been deposited a great thickness of sediments, mostly by the sea which has since receded from the eastern part of the basin. The resultant sedimentary rocks have been tectonically deformed and partly uplifted to form hills and mountains. Sediment is still being deposited along intervening valleys and canyons and into the sea , principally from the Santa Clara and Ventura Rivers. The Santa Clara River is a remnant of what was probably a much greater river system, whose earlier delta is preserved as the sediments of early to late Quaternary age underlying large areas in the eastern and central parts of the County, and beneath the Oxnard Plain. Santa Clara River deposits are presently the most important source of sand and gravel in the County.

The south half of the County has been one of the most significant sources of petroleum in California. This petroleum formed initially from marine organisms in fine-grained sediments deposited by the sea in the Ventura basin; it then migrated into various kinds of geologic traps including those created by folding and faulting due to compression from north to south during the last five to one million years. This folding and faulting has resulted in the Red Mountain, San Cayetano, Oak Ridge, Simi-Santa Rosa

**Represents portions of the report entitled "Geology and Mineral Resources Study of Southern Ventura County," July 1972, edited for inclusion in this document. The report with 5 plates can be purchased from the California Division of Mines & Geology, Los Angeles (Preliminary Report 14).*

and other fault zones which, in addition to being instrumental in the entrapment of petroleum, are potential sites for future earthquakes such as occurred to the east at San Fernando in 1971. An additional socio-economic factor resulting from the geologic framework is that clay-bearing marine siltstone and shale are particularly prone to landsliding in much of the region.

These positive and negative aspects of geology do not make southern Ventura County unique, except that unlike other parts of coastal southern California, urban development is only in an early stage. Even Simi Valley is not as yet completely developed. The rich soils of much of the Oxnard Plain and the Santa Clara River and other valleys still support a strong agricultutal industry, although urban development continues to expand. The communities of the Oxnard area also are slowly encroaching upon the sand and gravel operations of the Santa Clara River area. This reflects an ironic aspect of urban growth: the materials necessary for future construction are systematically covered by present development. The southeastern part of the study area includes the westernmost Santa Monica Mountains, with much of its wild, rocky beauty still preserved. Efforts to create a national park there already compete with demands for development to meet population growth.

An awareness of geologic factors is paramount to plans for developing communities. For example, there is a great need to know where faults or fault zones are located, which during an earthquake would yield damaging ground breaks, and to recognize conditions which cause some areas to be subject to amplified ground shaking. Another need is to utilize the lessons learned elsewhere. For example, the 1971 San Fernando earthquake illustrated that where thrust faults are activated during an earthquake it is safer to live on the lower plates (the area being overthrust) because effects of ground shaking and breaking tend to be less intense there than on the upper (overthrust) plates. Also important is that ground fills for building sites yielded to moderate and intense shaking during this earthquake. Soft, watery sediments amplify shaking considerably.

Citizens of Ventura County should appreciate the potential earthquake danger of such active and potentially active faults in the County as the San Cayetano thrust fault, north of the Santa Clara River Valley and east of Santa Paula. The steep cliffs above this fault have overridden the gentler slopes to the south and can be expected to do so again. The Red Mountain fault to the west is less dramatic, but nevertheless also is apparently active. In addition, the Oak Ridge, Simi-Santa Rosa, Camarillo, and other faults may be active. More needs to be learned about the potential seismic danger by studying the faults themselves and the sediments and land forms which have been affected by faulting in the fairly recent past.

An awareness of mineral economics relative to geology is also important. For example, should the sand and gravel industry be protected at its present locations, or are other economic sites available? Can an adequate supply of sand and gravel be developed from the alluvial fan deposits derived from Eocene rocks on the north side of Santa Clara Valley? The answers to these and related questions may affect the course of urbanization in the County.

In general, people must accommodate to geology, for geology does not generally accommodate to them. For example, if the Portuguese Bend landslide of the Palos Verdes Hills area of Los Angeles County had been properly recognized as a hazard before development, it could have been avoided or developed for non-hazardous use such as a park or in agriculture. Attempts to stabilize large landslides often prove frustrating.

APPENDIX A-II

NORTHERN VENTURA COUNTY*

A. GENERAL GEOLOGY

The north half of Ventura County lies within the Transverse Ranges which extend east-west from Santa Barbara through Riverside County for a total length of about 300 miles. The ranges are about 50 miles wide in the Ventura region, being bounded on the south by the Channel Islands and on the north by the Santa Ynez River.

Within the Ventura Region the ranges can be divided topographically and geologically into three units:

1. The Santa Ynez Mountains extend westward from the Ventura River. Their crest height within Ventura County is on the order of 4,000 feet. They consist mainly of Cretaceous to Quaternary sedimentary shale, sandstone and conglomerate.

2. The Topa Topa Mountains are the easterly continuation of the Santa Ynez Mountains and extend to lower Sespe Creek where the Piru Mountains begin and extend to Castaic. Much of these ranges have elevations up to 6,700 feet. Underlying bedrock, consists of mainly Tertiary shales, sandstones, conglomerates diatomaceous shale, and siltstones.

3. The Pine Mountain-Frazer Mountain ranges form a complex group of short, high and rugged ridges of sedimentary as well as granitic and metamorphic rocks. Elevations of the ridges range from 5,000 to over 8,000 feet above sea level.

During uplift of the ranges in the Ventura Region to the present elevations the crystalline rocks were thrust upward through the younger sedimentary rocks. Subsequent erosion of the highlands consisting of the older sedimentary (Tertiary age) and crystalline rocks resulted in deposition of the younger sedimentary (Quaternary age) formations in intervening broad valleys.

The present stage of uplift is such that erosion is the dominant sedimentary process. Valleys are relatively narrow and receive sediments (Pleistocene to Recent age) for only brief "storage." The past record of uplift indicates that the valley sediments are being incised by stream erosion with deposition of eroded materials occurring outside of the region.

The physiography of the north half represents a late youthful stage of the erosion cycle, and sharp, rugged ridges and narrow, steep-sided, deeply incised valleys are characteristic. Most of the streams are intermittent, flowing only during the winter

**Represents portions of the report entitled, "Reconnaissance Engineering Geology Report, North Half Phase II Study and Lockwood Valley Fault Trace Zoning and Land Use Study," August 1972, prepared by the County of Ventura, Department of Public Works.*

and spring seasons. The area contains many nonmarine terraces, upland valleys, fault-controlled valleys and canyons. Young alluvial fans being enlarged by deposition of sand, gravel and boulders are present at the mouth of most stream canyons.

B. GEOLOGIC STRUCTURE

The Transverse Ranges are unique to the western United States by virtue of their east-west trend. This apparent divergence from the normal north-south trend shown by the Sierra Nevada and Coast Ranges further north is believed caused by the compressional forces resulting from the tendency of an oceanic block of the earth's crust (Pacific Plate) to move northward relative to a continental block (Continental Plate). The line of demarcation between the plates is formed by the San Andreas Fault which borders the County to the north and northeast.

The compressional forces have apparently caused a north-south crustal shortening of many miles in the Ventura Region resulting in a series of east-west, steep sided folds, many of which are broken by thrust faults such as the San Cayetano and Frazier Mountain faults. Other faults showing considerable lateral and vertical displacements are the Santa Ynez and Big Pine faults. The region is structurally extremely complex in regard to the abundant crustal folding and faulting.

Much of the folding and faulting within the north half is believed to have occurred during Pleistocene time or during the past 3 million years. Evidence is strong that the forces causing deformation continue to be active at the present time. The recent San Fernando Earthquake, which resulted in the up-thrusting of a 100 ± square mile area of the San Gabriel Mountains several feet over the valley to the south, is believed to have been caused by compressional forces still active throughout the Transverse Ranges.

APPENDIX B-1

ALQUIST-PRIOLO GEOLOGIC HAZARD ZONES ACT

Public Resources Code CHAPTER 7.5. HAZARD ZONES

2621. This chapter shall be known and may be cited as the Alquist-Priolo Geologic Hazard Zones Act.

2621.5. It is the purpose of this chapter to provide for the adoption and administration of zoning laws, ordinances, rules, and regulations by cities and counties, as well as to implement such general plan as may be in effect in any city or county. The Legislature declares that the provisions of this chapter are intended to provide policies and criteria to assist cities, counties, and state agencies in the exercise of their responsibility to provide for the public safety in hazardous fault zones.

2622. In order to assist cities and counties in their planning, zoning, and building-regulation functions, the State Geologist shall delineate, by December 31, 1973, appropriately wide special studies zones to encompass all potentially and recently active traces of the San Andreas, Calaveras, Hayward, and San Jacinto Faults, and such other faults, or segments thereof, as he deems sufficiently active and well-defined as to constitute a potential hazard to structures from surface faulting or fault creep. Such special studies zones shall ordinarily be one-quarter mile or less in width, except in circumstances which may require the State Geologist to designate a wider zone.

Pursuant to this section, the State Geologist shall compile maps delineating the special studies zones and shall submit such maps to all affected cities, counties, and state agencies, not later than December 31, 1973, for review and comment. Concerned jurisdictions and agencies shall submit all such comments to the State Mining and Geology Board for review and consideration within 90 days. Within 90 days of such review, the State Geologist shall provide copies of the official maps to concerned state agencies and to each city or county having jurisdiction over lands lying within any such zone.

The State Geologist shall continually review new geologic and seismic data and shall revise the special studies zones or delineate additional special studies zones when warranted by new information. The State Geologist shall submit all such revisions to all affected cities, counties, and state agencies for their review and comment. Concerned jurisdictions and agencies shall submit all such comments to the State Mining and Geology Board for review and consideration within 30 days. Within 30 days of such review, the State Geologist shall provide copies of the revised official maps to concerned state agencies and to each city or county having jurisdiction over lands lying within any such zone.

2623. Within the special studies zones delineated pursuant to Section 2622, the site of every proposed new real estate development or structure for human occupancy shall be approved by the city or county having jurisdiction over such lands in accordance with policies and criteria established by the State Mining and Geology Board and the findings of the State Geologist. Such policies and criteria shall be established by the State Mining and Geology Board not later than December 31, 1973. In the development of such policies and criteria, the State Mining and Geology Board shall seek the comment and advice of affected cities, counties, and state agencies. Cities and counties shall not approve the location of such a development or structure within a delineated special studies zone if an undue hazard would be created, and approval may be withheld pending geologic and engineering studies to more adequately define the zone of hazard. If the city or county finds that no undue hazard exists, geologic and engineering studies may be waived, with approval of the State Geologist, and the location of the proposed development or structure may be approved.

2624. Nothing in this chapter is intended to prevent cities and counties from establishing policies and criteria which are stricter than those established by the State Mining and Geology Board, nor from imposing and collecting fees in addition to those required under this chapter.

2625. Each applicant for a building permit within a delineated special studies zone shall be charged a reasonable fee according to a fee schedule established by the State Mining and Geology Board. Such fees shall be set in an amount sufficient to meet, but not to exceed, the costs to state and local government of administering and complying with the provisions of this chapter. Such fee shall not exceed one-tenth of 1 percent of the total valuation of the proposed building construction for which the building permit is issued, as determined by the local building official. One-half of the proceeds of such fees shall be retained by the city or county having jurisdiction over the proposed development or structure for the purpose of implementing this chapter, and the remaining one-half of the proceeds shall be deposited in the General Fund.

SEC. 5. There is hereby appropriated from the General Fund in the State Treasury to the Department of Conservation the sum of one hundred thousand dollars ($100,000) for the purposes of Section 2622 of the Public Resources Code.

APPENDIX B-II

POLICIES AND CRITERIA OF THE STATE MINING AND GEOLOGY BOARD WITH REFERENCE TO THE ALQUIST-PRIOLO GEOLOGIC HAZARD ZONES ACT (CHAPTER 7.5, DIVISION 2, PUBLIC RESOURCES CODE, STATE OF CALIFORNIA)

(Adopted by State Mining and Geology Board November 21, 1973.)

The legislature has declared in the ALQUIST-PRIOLO GEOLOGIC HAZARD ZONES ACT that the State Geologist and the State Mining and Geology Board are charged under the Act with the responsibility of assisting the Cities, Counties and State agencies in the exercise of their responsibility to provide for the public safety in hazardous fault zones. As designated by the Act, the policies and criteria set forth hereinafter are limited to hazards resulting from surface faulting or fault creep. This limitation does not imply that other geologic hazards are not important and that such other hazards should not be considered in the total evaluation of land safety.

Implementation of the ALQUIST-PRIOLO GEOLOGIC HAZARD ZONES ACT by affected cities and counties fulfills only a portion of the requirement for these counties and cities to prepare seismic safety and safety elements of their general plans, pursuant to Section 65302 (F) and 65302.1 of the Government Code. The special study zones, together with these policies and criteria, should be incorporated into the local seismic safety and safety elements of the general plan.

The State Geologist has compiled and is in the process of compiling maps delineating special studies zones pursuant to Section 2622 of the Public Resources Code. The special studies zones designated on the maps are based on fault data of varied quality. It is expected that the maps will be revised as more complete geological information becomes available. Also, additional special studies zones may be delineated in the future. The Board has certain responsibilities regarding review and consideration of those maps prior to the time that they are finally determined. Cities, Counties and State agencies have certain opportunities under the Act to comment on the preliminary maps provided by the State Geologist and these Policies and Criteria. Certain procedures are suggested herein with regard to those responsibilities and comments.

Please note that the Act is not retroactive. Section 2623 of the Public Resources Code provides that it applies to every proposed new real estate development or structure for human occupancy.

REVIEW OF PRELIMINARY MAPS

The State Mining and Geology Board suggests that each reviewing governmental agency take the following steps in reviewing the preliminary maps submitted for their consideration:

1. All property owners within the preliminary special studies zones mapped by the State Geologist should be notified by the Cities and Counties of the inclusion of their lands within said preliminary special studies zones by publication or other means designed to inform said property owners. Such notification shall not of necessity require notification by service or by mail. This notification will permit affected property owners to present geologic evidence they might have relative to the preliminary maps.

2. Cities and Counties are encouraged to examine the preliminary maps delineating special studies zones and to make recommendations, accompanied by supporting data and discussions, to the State Mining and Geology Board for modification of said zones in accordance with the statute and within the time period specified therein.

3. For purposes of the Act, the State Mining and Geology Board regards faults which have had surface displacement within Holocene time (about the last 11,000 years) as active and hence as constituting a potential hazard. Upon submission of satisfactory geologic evidence that a fault shown within a special studies zone has not had surface displacement within Holocene time, and thus is not deemed active, the Mining and Geology Board may recommend to the State Geologist that the boundaries of the special studies zone be appropriately modified.

The definition of active fault is intended to represent minimum criteria only for all structures. Cities and Counties may wish to impose more restrictive definitions requiring a longer time period of demonstrated absence of displacements for critical structures such as high-rise buildings, hospitals, and schools.

SPECIFIC CRITERIA

The following specific and detailed criteria shall apply within special studies zones and shall be included in any planning program, ordinance, rules and regulations adopted by Cities and Counties pursuant to said GEOLOGIC HAZARD ZONES ACT:

A. No structure for human occupancy shall be permitted to be placed across the trace of an active fault. Furthermore, the area within fifty (50) feet of an active fault shall be assumed to be underlain by active branches of that fault unless and until proven otherwise by an appropriate geologic investigation and submission of a report by a geologist registered in the State of California. This 50-foot standard is intended to represent minimum criteria only for all structures. It is the opinion of the Board that certain essential or critical structures, such as high-rise buildings, hospitals, and schools should be subject to more restrictive criteria at the discretion of cities and counties.

B. Applications for all real estate developments and structures

for human occupancy within special study zones shall be accompanied by a geologic report prepared by a geologist registered in the State of California, and directed to the problem of potential surface fault displacement through the site, unless such studies are waived pursuant to Section 2623.

C. One (1) copy of all such geologic reports shall be filed with the State Geologist by the public body having jurisdiction within thirty days of submission. The State Geologist shall place such reports on open file.

D. Requirements for geologic reports may be satisfied for a single 1 or 2 family residence if, in the judgment of technically qualified City and County personnel, sufficient information regarding the site is available from previous studies in the same area.

E. Technically qualified personnel within or retained by each City or County must evaluate the geologic and engineering reports required herein and advise the body having jurisdiction and authority.

F. Cities and Counties may establish policies and criteria which are more restrictive than those established herein. In particular, the Board believes that comprehensive geologic and engineering studies should be required for any "critical" or "essential" structure as previously defined whether or not it is located within a special studies zone.

G. In accordance with Section 2625 of the Public Resources Code each applicant for a building permit within a delineated special studies zone shall pay to the City or County administering and complying with the ALQUIST-PRIOLO GEOLOGIC HAZARD ZONES ACT a fee of one-tenth of one-percent of the total valuation of the proposed building construction for which the building permit is issued as determined by the local building official.

H. As used herein the following definitions apply:

1. A "structure for human occupancy" is one that is regularly, habitually or primarily occupied by humans.

2. A geologist registered in the State of California is deemed to be technically qualified to evaluate geologic reports.

3. Any engineer registered in the State of California in the appropriate specialty is deemed to be technically qualified to evaluate engineering reports in that specialty.

APPENDIX B-III

EXPLANATION OF SPECIAL STUDIES ZONES MAPS
COMPILED BY THE STATE GEOLOGIST

Requirements

Maps showing special studies zones were compiled in compliance with Chapter 7.5, Division 2, of the California Public Resources Code. This Chapter, which may be cited as the Alquist-Priolo Geologic Hazards Zones Act, requires the State Geologist to 1) "delineate, by December 31, 1973, appropriately wide special studies zones to encompass all potentially and recently active traces of the San Andreas, Calaveras, Hayward, and San Jacinto Faults ... "and such other faults ..." that "... constitute a potential hazard to structures from surface faulting or fault creep"; and 2) compile maps of special studies zones and submit such maps to affected cities, counties, and state agencies by December 31, 1973, for their review and comment. Following appropriate reviews, the State Geologist must provide "official maps" to the affected cities, counties, and state agencies.

The State Geologist also is required to "continually review new geologic and seismic data" in order to revise the special studies zones or delineate additional zones.

This chapter requires cities and counties to exercise specified approval authority with respect to real estate development or structures for human occupancy within the special studies zones. Specific Policies and Criteria to assist local jurisdictions are provided by the State Mining and Geology Board. Other requirements and guidelines are provided in the Alquist-Priolo Act.

Special Studies Zones

Special studies zones are delineated on topographic base maps at a scale of 1:24,000 (1 inch equals 2000 feet). The zone boundaries are straight-line segments defined by turning points. Each turning point is identified by a number on the map for reference.

The intent of the Alquist-Priolo Act is to provide for public safety from the hazard of fault rupture by avoiding, to the extent possible, the construction of structures for human occupancy astride hazardous faults. The precise location and identification of hazardous faults within or near a zone of potentially active faults can be determined only through detailed geologic investigations. Thus, this Act establishes the concept of a Special Studies Zone -- an area of limited extent centered on recognized faults. Faults other than those depicted on the maps may be present within the Special Studies Zones. The zone boundaries delimit the area that the State Geologist believes warrants special geologic investigations to detect the presence or absence of hazardous faults.

Locations of special studies zone boundaries are controlled by the traces of potentially active faults (defined below), which are based on the best data available at the time the map was compiled. However, the faults shown on the Special Studies Zones maps were not field checked during the compilation of these maps. Because available fault data are highly varied in quality and the locations of some faults are known imprecisely, the zone boundaries have been positioned at a reasonable distance (about 660 feet or an eighth of a mile) from the trace of the nearest potentially active fault. However,

zone boundaries generally are more or less than 660 feet away from mapped faults because of 1) curved or multiple fault traces, 2) of the need to keep the number of turning points to a reasonable minimum, or 3) the quality of the data dictates a narrower or wider zone.

Definitions of Fault Terms

Fault, fault zone

A fault is defined as a fracture or zone of closely associated fractures along which rocks on one side have been displaced with respect to those on the other side. Most faults are the result of repeated displacement which may have taken place suddenly and/or by slow creep. A fault zone is a zone of related faults which commonly are braided and subparallel, but may be branching and divergent. It has significant width (with respect to the scale at which the fault is being considered, portrayed, or investigated), ranging from a few feet to several miles.

Fault trace

A fault trace is the line formed by the intersection of a fault and the earth's surface. It is the representation of a fault as depicted on a map, including maps of the Special Studies Zones.

Potentially active faults

For the purposes of delineating Special Studies Zones, any fault considered to have been active during Quaternary time (last 3,000,000 years)-- on the basis of evidence of surface displacement -- is con-

sidered by the State Geologist to be potentially active. An exception is a Quaternary fault which is determined, from direct evidence, to have become inactive before Holocene time (last 11,000 years). Such a fault is presumed to be essentially inactive and has been omitted from the map in most cases. Although faults shown on the maps may have been active during any part of, or throughout, Quaternary time, evidence for the recency of displacement is incompletely preserved and often is equivocal. In contrast, the State Mining and Geology Board, in their Policies and Criteria (adopted November 21, 1973), has defined any fault which has had surface displacement within Holocene time as "active and hence as constituting a potential hazard."

The surface ruptures associated with historic earthquake and creep events are identified where known. No degree of relative potential for future surface displacement or degree of hazard is implied for the faults shown.

The following geologic time scale is provided for reference and perspective:

GEOLOGIC TIME SCALE
(Abbreviated)

Geologic Age			Years before present (estimated)
Era	Period	Epoch	
CENOZOIC	QUATERNARY	"Historic"	200
		HOLOCENE	11,000
		PLEISTOCENE	2,000,000 - 3,000,000
	TERTIARY	PLIOCENE	7,000,000 - 10,000,000
		pre-PLIOCENE	65,000,000
pre-CENOZOIC time			
Beginning of geologic time			4,600,000,000

Faults defined as <u>active</u> by Policies & Criteria of the State Mining & Geology Board.

Faults defined as <u>potentially active</u> for the purpose of delineating special studies zones.

Uses and Limitations of Special Studies Zones Maps

Users of these maps should be fully aware that the zones are delineated to define those areas within which special studies may be required prior to building structures for human occupancy. Traces of potentially active faults are shown on the maps mainly to justify the locations of zone boundaries. These fault traces are plotted as accurately as the sources of data permit; yet the plots are not sufficiently accurate to be used as the bases for set-back requirements.

The State Geologist has identified potentially active faults in a broad sense, and the evidence for the potential activity of some faults may be only weak or indirect.

The fault information shown on the maps is not sufficient to meet the requirement for special studies. The onus is on the local governmental units to require the developer to evaluate specific sites within the special studies zones to determine if a potential hazard from any fault, whether heretofor recognized or not, exists with regard to proposed structures and their occupants.

STATE OF CALIFORNIA • THE RESOURCES AGENCY • DEPARTMENT OF CONSERVATION

CALIFORNIA DIVISION OF MINES AND GEOLOGY

DIVISION HEADQUARTERS
RESOURCES BUILDING
ROOM 1341
1416 NINTH STREET
SACRAMENTO CA 95814

CDMG NOTES NUMBER 37

GUIDELINES TO GEOLOGIC/SEISMIC REPORTS

The following guidelines are taken from "Geology and earthquake hazards: Planners guide to the seismic safety element" prepared by Grading Codes Advisory Board and Building Code Committee of the Southern California Section, Association of Engineering Geologists, July, 1973. They are reprinted here courtesy of the Association of Engineering Geologists.

I. *Introduction*

This is a suggested guide or format for the seismic section of engineering geologic reports. These reports may be prepared for projects ranging in size from a single lot to a master plan for large acreage, in scope from a single family residence to large engineered structures, and from sites located on an active fault to sites a substantial distance from the nearest known active fault. Because of this wide variation, the order, format, and scope should be flexible and tailored to the seismic and geologic conditions, and intended land use. The following suggested format is intended to be relatively complete, and not all items would be applicable to small projects or low risk sites. In addition, some items would be covered in separate reports by soil engineers, seismologists, or structural engineers.

II. *The Investigation*

A. *Regional Review*

A review of the seismic or earthquake history of the region should establish the relationship of the site to known faults and epicenters. This would be based primarily on review of existing maps and technical literature and would include:

1. Major earthquakes during historic time and epicenter locations and magnitudes, near the site.

2. Location of any major or regional fault traces affecting the site being investigated, and a discussion of the tectonic mechanics and other relationships of significance to the proposed construction.

B. *Site Investigation*

A review of the geologic conditions at or near the site that might indicate recent fault or seismic activity. The degree of detail of the study should be compatible with the type of development and geologic complexity. The investigation should include the following:

1. Location and chronology of local faults and the amount and type of displacement estimated from historic records and stratigraphic relationships. Features normally related to activity such as sag ponds, alignment of springs, offset bedding, disrupted drainage systems, offset ridges faceted spurs, dissected alluvial fans, scarps alignment of landslides, and vegetation patterns, to name a few, should be shown on the geologic map and discussed in the report

2. Locations and chronology of other earthquake induced features caused by lurching, settlement, liquefaction, etc. Evidence of these features should be accompanied with the following:

   a. Map showing location relative to proposed construction.

   b. Description of the features as to length, width and depth of disturbed zone.

   c. Estimation of the amount of disturbance relative to bedrock and surficial materials

3. Distribution, depth, thickness and nature of the various unconsolidated earth materials, including ground water, which may affect the seismic response and damage potential at the site should be adequately described.

C. *Methods of Site Investigation*

1. Surface investigation

   a. Geologic mapping.

   b. Study of aerial photographs.

   c. Review of local ground water data such as water level fluctuation, ground water barriers or anomalies indicating possible faults.

2. Subsurface investigation

   a. Trenching across any known active faults and suspicious zones to determine location and recency of movement, width of disturbance, physical condition of fault zone materials, type of displacement and geometry

Address mail orders to the California Division of Mines and Geology, Post Office Box 2980, Sacramento, California 95812. Checks and Money Orders should be made payable to the California Division of Mines and Geology. Please do not send stamps in payment. Publications may be purchased over-the-counter at the three District Offices: Sacramento, Room 118, Resources Building, 1416 Ninth Street; San Francisco, Room 2022, Ferry Building; Los Angeles, Room 1065, Junipero Serra Building, 107 South Broadway.

b. Exploratory borings to determine depth of unconsolidated materials and ground water, and to verify fault-plane geometry. In conjunction with the soil engineering studies, obtain samples of soil and bedrock material for laboratory testing.

c. Geophysical surveys which may indicate types of materials and their physical properties, ground water conditions, and fault displacements.

III. *Conclusions and Recommendations*

At the completion of the data accumulating phase of the study, all of the pertinent information is utilized in forming conclusions of potential hazard relative to the intended land use or development. Many of these conclusions will be revealed in conjunction with the soil engineering study.

A. *Surface Rupture Along Faults*

1. Age, type of surface displacement, and amount of reasonable anticipated future displacements of any faults within or immediately adjacent to the site.

2. Definition of any areas of high risk.

3. Recommended building restrictions or use-limitations within any designated high risk area.

B. *Secondary Ground Effects*

1. Estimated magnitude and distance of all relevant earthquakes.

2. Lurching and shallow ground rupture.

3. Liquefaction of sediments and soils.

4. Settlement of soils.

5. Potential for earthquake induced landslide.

IV. *Presentation of Data*

Visual aids are desirable in depicting the data and may include:

A. *General data*

1. Geologic map of regional and/or local faults.

2. Map(s) of earthquake epicenters.

3. Fault strain and/or creep map.

B. *Local or site data*

1. Geologic map.

2. Geologic cross-sections illustrating displacement and/or rupture.

3. Local fault pattern and mechanics relative to existing and proposed ground surface.

4. Geophysical survey data.

5. Logs of exploratory trenches and borings.

V. *Other Essential Data*

A. *Sources of data*

1. Reference material listed in bibliography.

2. Maps and other source data referenced.

3. Compiled data, maps, plates included or referenced.

B. *Vital support data*

1. Maximum credible earthquake.

2. Maximum probable earthquake.

3. Maximum expected bedrock acceleration

C. *Signature and license number of geologist registered in California*

JES

APPENDIX C-II

ASSOCIATION OF ENGINEERING GEOLOGISTS

ANNUAL MEETING - OCT. 1978

STRUCTURAL ENGINEERS ASSOCIATION OF SOUTHERN CALIFORNIA
PANEL DISCUSSION

"STANDARDIZATION OF GEOLOGIC REPORTS AND SEISMIC EVALUATIONS"

OUTLINE FOR SEISMIC EVALUATION OF A SITE

When it is deemed necessary to provide seismic design information for the site of a proposed structure, the following procedure should be performed by the owner's geotechnical consultant. The geotechnical consultant should be a coordinated team experienced in the fields of soil and foundation engineering, engineering geology, engineering seismology and earthquake engineering.

I. A preliminary reconnaissance of the site and a review of published data shall be made by the geotechnical consultant to determine if there is the likelihood of one of the following hazards being present on the site.

1. An active fault.
2. Conditions which may produce liquefaction of foundation material, hazardous landsliding, or other ground failure.
3. Location which could result in damage due to tsunamis of seiches.
4. Geologic conditions which may influence ground shaking during an earthquake.

The report to the owner should contain the geotechnical consultant's best judgment as to the probability of any of these hazards existing. If any appear very probable, the geotechnical consultant should submit a proposal to the owner for additional field work that may be necessary to more accurately determine the probability of these hazards. The architect and design engineer should assess the information and make recommendations to the owner for further work if required.

II. Based on conclusions resulting from the preliminary reconnaissance study outlined in (I) above, further investigation may be required. The geotechnical consultant should thoroughly study the likelihood of active faulting, liquefaction, hazardous landsliding or other ground failure, and/or tsunamis or seiches. An evaluation of these conditions should be presented in terms of positive conclusions and recommendations for design. Design recommendations should be developed in consultation with the owner, architect and/or design engineer.

III. If it is deemed appropriate as part of the subsequent work, particularly for major structures, a definition of the ground shaking should be provided by the geotechnical consultant. One or more design earthquakes should be considered in developing the recommendations.

A. The steps involved in the analysis may include:

1. Determination of the location of active faults which may affect the site and the definition of potential earthquakes which may occur on such faults or other source areas:
2. Evaluation of the statistical seismicity of the site.
3. Evaluation of the dynamic characteristics of the site with respect to the amplification or attenuation of bedrock motions; and

4. Selection of the ground motions and preparation of design recommendations. The selection of the design earthquakes and ground motions should be made in consultation with the owner, architect and/or design engineer. The factors to be considered in the selection may include: (a) The probability of earthquake occurrence during the useful life of the structure; (b) Earthquakes magnitude; (c) The economics of construction; (d) The importance of the structure in terms of service to the public and consequences of failure; and (e) The occupancy of the structure.

B. The design recommendations information should be presented in one or more of the following formats. The proper format should be selected in conjunction with the design engineer.

1. **Design Ground Acceleration.** Design ground acceleration for the site to be used by the structural engineer as a basis for designing extremely rigid (T—.1 sec.) one and two-story structures where the response of the structure because of its rigidity may be assumed to be identical to that of the site.
2. **Design Structural Response Acceleration.** Structural acceleration anticipated based on evaluation of the response of single degree of freedom elastic systems (period range of 0.1 sec. to 0.5 sec.) to the anticipated ground motion for the site. This acceleration should be developed for a level of damping consistent with the type of structure proposed, and should be used in designing structures falling in this category (i.e., more flexible one-story structure to stiffer five-story structures) where spectral techniques are utilized.
3. **Elastic Structural Response Spectra.** A smoothed response spectra presenting the response of a single degree of freedom elastic system (period range from 0.1 sec. to 4.0 sec.) to site ground motion is presented, usually on a tripartite plot. This response spectra may be used by the structural engineer in designing more flexible structures utilizing spectral techniques.
4. **Time-History Plot of Predicted Ground Motion at the Site.** Ground displacement, or acceleration at the site, is presented as a function of time. Usually this should be available in the form of a punched data deck.
5. **Other Data—Standard Seismicity.** Previously developed earthquake data deemed appropriate for the site and the proposed structure may be used. This can be presented in the form of any of the above four formats. Concurrence with the design engineer should be obtained on any limitations of frequencies to be considered.